AN ENERGY BLACK SWAN?

THROUGHOUT HISTORY, ENERGY DEVELOPMENT HAS BEEN LITTERED WITH BLACK SWAN EVENTS – OCCURRENCES THOUGHT TO BE SO UNLIKELY THEY WERE CONSIDERED IMPOSSIBLE, UNTIL THEY HAPPENED.

Since the industrial revolution, humanity has struggled to keep up with its own energy consumption needs. As carbon emissions continue to escalate, the planet's resources become increasingly constrained. Add global population growth and rapid urbanization to the mix and you have the makings of the perfect energy storm. The only way to enable continued growth and development is to establish stable, reliable, accessible alternative energy sources.

While newcomers are changing the global energy landscape, humanity's appetite for energy remains insatiable. A sustained shift towards renewable, 'green' energy sources has resulted in an enormous capital and effort investment in resource exploration and energy generation and transmission.

Throughout history, the development of energy sources has been littered with unpredictable turns, many resulting in significant financial and human losses. In 2007, Nassim Nicholas Taleb used the metaphor of a 'black swan' to describe high impact events thought to be so unlikely they were considered impossible, until they happened. Many of our energy exploration watershed moments have, indeed, been black swan events, changing the trajectory of numerous countries and economies over the years.

The invention of the modern solar-electric cell could be seen as one such black swan event, discovered in the 1950s largely by accident when researchers were exploring the properties of silicon semiconductors. As the technology is refined, solar power becomes cheaper and more effective. Solar power is now ~85% cheaper than it was a decade ago, and this cost-efficiency has resulted in a number of global space agencies launching studies into the feasibility of space-based solar power plants. Although cost-efficiency is an alluring prospect, it is certainly not the only driver.

In contrast to terrestrial arrays, space-based solar arrays are exposed to constant sunshine with no interference from clouds or impurities in the air. The $455 million market is expected to almost double in size over the next 5 years as more companies and governments invest. Early movers in the space include American-based, Airborne, and Germany's AZUR Space Solar Power, which have already made significant investments; and the UK and Saudi Arabian governments recently announced a joint investment to develop a space-based solar plant.

Another alternative many people hope will fuel our energy needs into the future is hydrogen power, particularly for sectors considered difficult to decarbonize, such as mining. Hydrogen is seen as an 'all-rounder' because it can

be used as an energy carrier as well as a resource in energy and heat generation, transport, and buildings. Thanks to its versatility, more than 30 countries have already released hydrogen roadmaps and in excess of 200 hydrogen projects have been announced. EPRO Advanced Technology has successfully locked hydrogen into a powder from, released through the addition of water. This advancement significantly simplifies the transportation of hydrogen and could change the entire value chain as we know it, accelerating hydrogen production, transmission, distribution, retail, and end-applications.

Hydrogen produced using renewable energy could enable emissions-intensive industries to reduce their overall emissions in a variety of ways. One application is to generate electricity from fuel cells by converting green hydrogen back into electricity. In this way, green hydrogen can not only be used as a fuel, but also to generate heat in buildings or power vehicles. Despite the obvious benefits, the penetration of hydrogen-powered vehicles is relatively low because they are expensive and require specialized hydrogen filling station networks. However, these obstacles are gradually being overcome, with Germany having set the target to have 200 hydrogen filling stations by the end of 2023.

Hydrogen is also seen as a viable power source for other vehicle types, from industrial trucks and rail transport to planes and cargo and cruise ships. China and Germany are already testing hydrogen-powered trains, with many other countries set to follow suit, and Airbus has made great strides with its ZEROe concept hybrid-hydrogen aircraft, while hydrogen-powered cargo ships are increasingly being seen on the world's oceans.

Despite the technological advances, green hydrogen technology remains cost-intensive with high manufacturing costs being a key barrier to the technology becoming more mainstream. At the same time, hydrogen aspirations compete with other green technology applications, especially those that are already mature, such as electromobility, lithium-ion energy storage systems, or digital energy efficiency systems. Without extensive financing and organizations willing to take the risk, the development of the hydrogen economy will remain stunted.

These evolving technologies will create massive disruption in traditional, oil-, gas-, chemical-, and mineral-processing industries, and global energy companies stand to lose billions of dollars if they fail to transition away from fossil fuels. One might argue that this is the reason we will never fully transition away from fossil fuels, that we will be held to ransom by those companies and countries who stand to lose the most. Which begs the question, is the world heading towards an energy war? Could another black swan event be brewing?

Of course, this is only one of the market spaces where disruptive forces are at work and game-changing new investment opportunities might be discovered.

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